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MALE TRANSFER OF MATERIALS TO MATES IN THE CARIBBEAN FRUIT FLY, *ANASTREPHA SUSPENSA* (DIPTERA: TEPHRITIDAE)

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ABSTRACT

In the Caribbean fruit fly, *Anastrepha suspensa* (Loew), females prefer to mate with large males. One explanation for this preference is a greater paternal investment passed in the ejaculate of bigger males. Tests conducted with radioactive males indicate

that material from males moves from the spermathecae into unfertilized eggs in the ovaries and somatic tissue, suggesting female use of male resources. However, the amount of substance transferred was so small (an estimated 0.0001 of the male's body weight) that its role as a paternal investment and the basis of female choice is questionable.

Resumen

Hembras de la mosca del Caribe, *Anastrepha suspensa* (Loew) prefieren acoplarse con machos grandes. Una explicación de esta preferencia es la de una inversión paternal que es pasada en la ejaculación de los machos más grandes. Pruebas hechas con machos radioactivos indican que el producto de los machos se mueve de la espermacica hacia los huevos no fertilizados en los ovarios y los tejidos somáticos, sugiriendo el usa de recurso de los machos por las hembras. Sin embargo, la cantidad de sustancias transferidas fue tan pequeña (un estimado de 0.0001 del peso del macho), que su papel como una contribución paternal y como base de preferencia de las hembras es puesto en duda.

The basis of female mate choice is thought to be either genetic or material (Thornhill 1980, 1984). In the former, a female chooses the best available genes to incorporate into her offspring. In the second, she increases her fecundity/survival (or that of her offspring) by coupling with males who offer a resource or provide a service. This resource can take a number of forms, e.g. dead insects, seeds, protection from predators, or access to oviposition sites (Thornhill & Alcock 1983). Even the substance of an ejaculate, both accessory gland fluids and sperm, represents a potential "meal" (Sivinski 1980, 1984a). In some extreme and suspicious cases, females have enormous stomach-like sperm storage organs complete with digestive enzymes (e.g. Blackwith 1973). Selection for male investment can find in male genitals a convenient conduit for its transfer. By increasing the volume or the nutritional value of his ejaculate, a male could pass substantial material to his mate. Considerable reproductive tract-originating investments do occur in the spermatophores of Lepidoptera (Boggs & Gilbert 1979, Rutowski 1982) and Orthoptera (Gwynne 1983). Among the Diptera, multiple-mated *Drosophila pseudoobscura* Fralova females have greater fertility, suggesting that they have acquired multiple investments (Turner & Anderson 1983). *Drosophila mojavensis* Patterson & Crow mates daily and substances passed by the male contribute to female somatic tissue and developing oocytes (Markow & Ankney 1984).

Female choice plays an important role in the mating system of the Caribbean fruit fly, *Anastrepha suspensa* (Loew). Males form aggregations (leks) on host plant foliage to which females come and apparently "shop" for mates (Burk 1981). While on their leaf-territories, males broadcast visual, acoustic, and pheromonal displays at least some of which seem to be advertisements of size, large size being a trait females prefer in a mate (Sivinski et al. 1984, Sivinski & Burk 1987). We here address why females might have such a preference; i.e., is there an ejaculate based male paternal investment, one that could be more substantial coming from larger males?

Methods

We wished to determine if any labeled materials passed by males to females were eventually found in unfertilized eggs. In order to do so, male *A. suspensa,* on the day of their eclosion, were placed on a diet of powdered sugar, protein hydrolysate, water and radioactive phosphorous (^{32}P). Patterson et al. (1968) and Smittle et al. (1969) reported that ^{32}P uniformally labeled male reproductive organs in mosquitoes and that the amount of radioactivity transferred to females during mating was correlated to the total amounts of radioactivity in the male. In the first test this diet registered 33,000 counts/min per mg, and in the second, 62,000 counts/min per mg. After 7 days, the radioactive food was replaced by a nonradioactive mixture. The flies were kept on this diet for 2 days to clean the gut of radioactive material. Males were then placed with virgin females in individual cages that contained sugar and water, and their sexual behavior was noted (n = 26 first test, n = 24 second test).

As mated pairs completed copulation, they were alternately placed into either a group for immediate dissection (within 2 h) or set aside for dissection 24 h later. In the 24-h group, males were removed after copulation was completed and the cages checked with a portable radiation survey meter for radioactively contaminated materials that a female might consume before being dissected. If such were found, the cage was replaced. Dissections were done under a binocular microscope on 12-mm diam glass cover slips.

The ovipositor, spermathecae and adjacent glands were placed between two cover slips and then pressure was applied to rupture the spermathecae and free the sperm. The presence of sperm was determined using a phase microscope. Then the cover slips with the spermathecae and connecting tissue were placed in vials with Packard Scint-A® liquid scintillation cocktail and assayed for radioactivity. Ovaries and the remainder of the bodies were placed on cover slips and likewise put into a liquid scintillation cocktail for assay. In the first test, the average background radioactivity level was subtracted from each sample. In the second test, a 10-min background count was made of each vial and this count was subtracted from the tissue counts.

In an attempt to determine if larger males deposited a greater amount of material, we correlated male size with the radioactivity levels in the ovaries and spermathecae of their mates. Male size was determined by measuring wing length with an optical micrometer.

RESULTS

The amount of radioactivity in the males and females of the two replicates differed by more than an order of magnitude (Table 1). However, the trend toward increasing radioactivity over time was the same in both the unfertilized eggs of the ovaries and

TABLE 1. THE MEAN RADIOACTIVITY (COUNTS/MIN) IN MALES AND IN THE OVARIES (OV), SPERMATHECAE (sp), AND BODY (B) OF FEMALES, LESS THAN 2 AND 24 H AFTER MATING. STANDARD DEVIATIONS ARE IN PARENTHESIS.

<2 h females				24 h females			
OV	sp	B	♂	OV	sp	B	♂
			First replicate				
0.51	1.78	1.2	20418	9.7	2.3	23.7	23185
(.74)	(1.2)	(2.4)	(5639)	(21.7)	(4.9)	(63.1)	(5527)
			Second replicate				
34.6*	63.3	71.4	905512	44	26.4	81.1	1699688
(45.8)	(35.3)	(48.2)	(299089)	(33.6)	(14.2)	(78.8)	(261100)

*Two atypical counts were excluded from the calculation of these means.

body tissue (see Table 2). There was no correlation in the second (higher count) replicate between the radioactivity of the male and the amount of radioactivity in the reproductive system of his mate (>2-h, $r = 0.02$, $n = 9$, $p = 0.97$; 24-h, $r = 12$, $n = 8$, $p = 0.77$; for a case where such a correlation dose occurs in a dipteran, see Smittle & Patterson [1970]). This transferred amount tended to be a very small portion of the males' body weight ($\forall\chi = 0.0001$, $S = 0.0002$). To estimate the proportion of male weight transferred, we assume that radioactive phosphorous is distributed evenly in the males' body, an assumption borne out in studies of other Diptera (e.g. Patterson et al. 1968, Smittle et al. 1969).

There was no significant correlation between the proportion of a male's radioactivity found in his mate and male size ($r = -0.29$, $n = 17$, $p > 0.25$). Either there is no allometric relationship between male size and the quantity of the ejaculate or there was a large amount of variance in the amount of label the males ingested originally.

Discussion

Some male tephritids provide their mates with considerable amounts of material in the form of salivary droplets and foams (Burk 1981). The behavior of *A. suspensa* suggests that perhaps a more cryptic investment is passed. In the laboratory, aggressive females butt at copulating pairs in what seems to be an attempt to gain access to males. A postcopulatory lack of male attractiveness suggested the possibility of an investment that females sought and which was exhausted temporarily by copulation

Table 2. The numbers of instances where spermathecae (sp) were more radioactive than ovaries (OV) or bodies (B) and vice versa at less than 2 h after mating.

	<2 h	24 h
	First replicate	
OV > sp	1	9
sp > OV	12	2
($\chi^2 = 10.4$, $p < 0.005$)		
B > sp	3	10
sp > B	10	3
($\chi^2 = 4.2$, $p < 0.005$)		
	Second replicate	
OV > sp	3	7
sp > OV	9	2
($\chi^2 = 3.8$, $p = 0.05$)		
B > sp	6	10
sp > B	6	0
($\chi^2 = 4.8$, $p < 0.05$)		
	Summed	
OV > sp	4	16
sp > OV	21	4
($\chi^2 = 15.4$, $p < 0.001$)		
B > sp	9	20
sp > B	16	3
($\chi^2 = 11.0$, $p < 0.001$)		

(Sivinski 1984b). That this explanation need not be the case is illustrated by *Drosophila melanogaster* Meigan, which has a period of postcoital male unattractiveness, but does not provide females with resources in the ejaculate (Markow et al. 1978, Markow & Ankney 1984). The very nature of the mating system, signaling males and searching females, is one that is often associated with male investment (Thornhill & Alcock 1983). However, the propensity for infrequent or single matings is inconsistent with what might be in a female's best interests, i.e. garnering resources from several mates (Markow & Ankney 1984, but see Gwynne 1984).

In the Caribbean fruit fly, only one ten-thousandth of the males' weight reaches the female reproductive system. Barring the male's passing some compound expensively obtained or synthesized, this infinitesimal amount is hardly comparable to the massive paternal investments of certain Orthoptera and Lepidoptera (e.g. 27% of body weight, Gwynne 1981). The suspected paternal investment of *D. majovensis* to unfertilized eggs is 15X that of *A. suspensa* in terms of proportion of body weight. On the other hand, there is a flow of material from the spermathecae to the female body and her unfertilized eggs. Our results then are somewhat ambiguous. Even if different sized paternal investments were offered by various sized males, it is our impression that such small differences are unlikely to be the basis of female choice of larger mates. For instance, a 10% difference in male size might yield only a 0.00001 of a male's total weight increase in ejaculate size. The more likely alternative seems to be that females choose large male phenotypes as predictors of correlated genes.

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TRUNK TRAPS AND OVERWINTERING PREDATORS IN PECAN ORCHARDS: SURVEY OF SPECIES AND EMERGENCE TIMES

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ABSTRACT

Three types of traps placed at ca. 1 m above ground on the trunks of pecan trees from November, 1985 to 15 February, 1986 were compared to pecan bark samples for populations of overwintering predators. Traps were ca. 15 x 100 cm and consisted of the following: 1). burlap trap—modified after Tedders (1974), 2). filter trap—a piece of greenhouse Coolpad® in a UV protected plastic bag with holes, 3). cardboard trap—modified from Tamaki and Halfhill (1968). An equivalent area of bark was the control. A portion of the traps were dissected for their contents in the laboratory. Other traps were retained in cardboard emergence boxes under Albany, GA field conditions and emergence of the predators was recorded in Spring 1986.

The coccinellid beetle, *Olla v-nigrum* (Mulsant), a green lacewing, *Chrysopa nigricornis* Burmeister, and spiders were found consistently in the traps and the bark. Low numbers of larvae of the brown lacewing, *Micromus posticus* (Walker), a mirid, *Deraeocoris nebulosus* (Uhler), the anthocorid, *Orius insidiosus* (Say), and miscellaneous reduviids were also detected. Earwigs, *Doru taeniatum* (Dohrn). Forficulidae, were ubiquitously present on the trees. A late season pentatomid pest of pecan nuts and agronomic crops, *Nezara viridula* (L.), overwintered in the traps in higher numbers